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Dissipation: Ways, Deviations, and Progress

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Operational and Thermophysiological Needs for Metabolic Heat Dissipation: Ways, Deviations, and Progress

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I. Introduction:

The human body regulates the core temperature neurophysiological by vasomotoric actions, muscle work, general behavior, sweat production and heat production by the brown fat tissue.

The centre is the hypothalamus. Cooling the spine or the head has direct input to the regulation centre.

In hyperthermia all regulation devices work at it's maximum – not in the state of fever!

This is a very bad sensation for the human body.

Hyperthermia decreases the mental and physiological performance dramatically and may lead to death.

All these regulations are very complex and not scientifically known in all details.

To make it even more difficult you have to consider the individual heat tolerance, the amount of body fat, mental and physical workload and environmental factors (e.g. relative humidity, temperature, wind speed, clothing).

Our task is to keep the heat stress as low as possible because of two reasons:

1. to protect the man and his health
2. to keep man's performance at it's maximum

II. Mainpart:

In environmental medicine the first goal is to make the work place as adequate to human belongings as possible by technical means.

If there are no other technical solutions possible you have to protect the man himself.

The clothing itself counteracts the physiological thermoregulation because sweat is disturbed to evaporate, humidity between skin and clothing is saturated pretty soon; workload is higher with protective clothing (additional weight, decreased mobility), wind speed cannot reach the skin, etc..

Examples of the influence of wind speed, normal clothing, water vapour resistant clothing are demonstrated.

Several ways of protection clothing are in service:

1. Clothing with heat reflecting surface
 advantage: - protection good
 disadvantage: - protection only for a very limited time
 - evaporation of sweat impossible
 - weight
 - decreased mobility
 - no physiological thermoregulation
2. Cooling jackets with closed bags inside, bags are filled: either with cooled water or carbon dioxide snow
 advantage: good cooling effect
 disadvantage: - weight 5 kg
 - ice may not have direct contact to skin (two reflecting layers inside)
 - no physiological heat regulation
 - limited time
3. Cold bags are worn like a back pack. They have to be protected against the heat from the outside (radiation).
 advantage: - selective cooling of a limited region
 disadvantage: - extra weight (5 kg);
 - surrounding heat (extra weight, mobility)
 - no physiological heat regulation
4. Two layered protection suit with cooled compressed air and heat reflectors
 advantage: - temperature of 100°C possible
 disadvantage: - weight
 - noise
 - very limited mobility;
5. Liquid cooled vest (Ef 2000)
 advantage: - good performance, good during flight
 disadvantage: - weight for apparatus (15 Kg) on the way to and from the aircraft
 - only apparatus at home base
 - no physiological heat regulation.

III. Progress

If you look at all ways to overcome the problems with heat stress they have one thing in common: they are not using the physiological way of cooling: give the body the possibility to sweat, transport the humidity away and keep an air stream close to the body by much better mobility and independent of power sources.

This is pretty good realized by a full coverage suit that fulfills all these needs.

Summary:

The thermophysiological regulation of body temperature is partially or completely inhibited by protection suits especially when several qualities of protection are needed.

The result of an insufficient thermophysiological response is heat stress with decreased mental and physical performance of the human being.

To get an idea about the amount of heat stress different physiological values are measured: metabolic rate, heart frequency, mean skin and core temperature, sweat rate, psychological performance tests, loss of energy in W/cm^2 , etc. This variety of different data demonstrates the difficulty to get an exact picture how much heat stress can be tolerated under different circumstances.

Nobody doubts that technical cooling devices are necessary to keep the human performance tolerable and to avoid a collapse that may lead to death:
heat reflecting clothes, cooling jackets filled with water or carbon dioxide snow, two-layered protection suit with cool pressurized air, etc.

The best solution is the natural one:

1. allow the body to sweat and transport the humidity away to keep the environment as dry as possible to avoid a saturation of humidity surrounding the human body.
2. Clothing must not be close to the body in order to allow circulation of air to get rid of the evaporated sweat (chimney-effect).